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(71) Applicant: Canon Inc.

(72) Inventor: Tomokazu ANDO

(72) Inventor: Masahiro TAGAWA

(74) Agent: Patent Attorney, Tadashi Wakabayashi

(54) [Title of the Invention] IMAGING DEVICE

(57) [Abstract]

[Object] To provide an imaging device efficiently made to be lightweight without impairing the strength as an atmospheric resistant structure.

[Construction] The imaging device constructed as a vacuum vessel comprises a rear plate 1 mounting a group of electron emission elements (not shown) and electrodes (not shown), a face plate 2 facing the rear plate 1 and mounting an imaging member for forming an image by irradiation of an electron beam from the group of electron emission elements (not shown), and a supporting frame 3 disposed between the face plate 2 and rear plate 1 for supporting the circumference of the face plate and rear plate so as to surround the group of the electron emission elements. The width of each edge of

the supporting frame 3 is widened depending on an extension stress so that the extension stress acting on the outer circumference of the supporting frame becomes uniform when the rear plate and face plate are bent toward the inside of the vacuum vessel by the atmospheric pressure.

[Claims]

[Claim 1] An imaging device formed as a hermetic structure with a rear plate mounting elements and electrodes, a face plate disposed facing the rear plate and mounting an imaging member, and a supporting frame disposed between the rear plate and face plate,

wherein the width of the supporting frame is not uniform with a minimum with at the corners of the supporting frame, and side faces of the outer circumference of the supporting frame is outwardly swelled.

[Claim 2] The imaging device according to Claim 1, wherein the outer circumference of the supporting frame has a shape comprising a plurality of curved surfaces.

[Claim 3] The imaging device according to Claim 1, wherein the side faces of the outer circumference of the supporting frame has a shape comprising a plurality of curved surfaces and a plurality of planes.

[Claim 4] The imaging device according to Claim 2 or 3, wherein the curved surface is a part of the side face of a circular column or ellipsoidal column.

[Claim 5] The imaging device according to Claim 2 or 3, wherein the supporting frame comprises a plurality of side walls.

[Claim 6] The imaging device according to Claim 2 or 3, wherein the supporting frame comprises a plurality of side

walls and a plurality of reinforcing walls.

[Claim 7] The imaging device according to any one of Claims 4 to 6, wherein at least one of the face plate and rear plate has the same shape as the shape of the side faces of the outer circumference of the supporting frame.

[Claim 8] The imaging device according to Claim 7 using a surface conduction electron emission element as the element.

[Claim 9] The imaging device according to Claim 7 as a gas discharge imaging device.

[Claim 10] The imaging device according to Claim 7 as a thermoelectron emission imaging device.

[Detailed Description of the Invention]

[0001]

[Technical Field of the Invention] The invention relates to a flat imaging device.

[0002]

[Description of the Related Arts] A thermoelectron source and a cold cathode electron source have been known as electron emission elements. The cold cathode electron sources are classified into a field emission (abbreviated as FE) electron source, a metal/insulator/metal (abbreviated as MIM) electron source, and a surface conduction electron emission element.

[0003] Examples of the FE electron source known in the art

include those decried in "Field Emission" by W. P. Dyke and W. W. Dolan, Advance in Electron Physics, 8, 89(1956) and "Physical Properties of Thin-Film Field Emission Cathodes with Molybdenum Cones" by C. A. Spindt, J. Appl. Phys., 47, 5248 (1976).

[0004] Examples of the MIM electron emission source include those described in "The Tunnel-Emission Amplifier" by C. A. Mead, J. Appl. Phys., 32, 646 (1961).

[0005] Examples of the surface conduction electron emission element include those described in Radio Eng., by E. I. Elinson, Electron Phys., 10, 1290 (1965).

[0006] The surface conduction electron emission element utilizes a phenomenon in which electrons are emitted by permitting electrons to flow in parallel in a small area thin film surface formed on a substrate.

[0007] The surface conduction electron emission element reported includes those using a SnO_2 thin film reported by Elinson et. al., those using an Au thin film [G. Ditter, "Thin solid films", 9, 317 (1972)], using an In_2O_3/SnO_2 thin film [M. Hartwell and C. G. Fonstad, IEEE Trans., ED Conf., 519 (1975)], and those using a carbon thin film [Hisashi Araki e, al., Sinku (Vacuum). Vol. 26, No. 1, p22 (1983)].

[0008] The usual imaging device forming an image utilizing the electron emission element described above will be described with reference to Figs. 6 and 7.

[0009] Fig. 6 is a disassembled perspective view for illustrating the usual imaging device, and Fig. 7 is a vertical cross section of the imaging device shown in Fig. 6.

[0010] The imaging device usually comprises, as shown in Figs. 6 and 7, a rear plate 103 mounting a group of electron emission elements, a face plate 102 disposed to face the rear plate 103 and mounting an imaging member on which images are formed by irradiating an electron beam from the group of the electron emission elements, and a supporting frame 104 placed between the face plate 102 and rear plate 103 for supporting the circumferences of the face plate 102 and rear plate 103 so as to surround the group of the electron emission elements. The joints between the face plate 102 and supporting frame 104, and between the rear plate 103 and supporting frame 104 are bonded with a frit glass 101.

[0011] The method for assembling the usual imaging device will be described below. The frit glass 101 is coated on the joint faces of the face plate 102 and rear plate 103, respectively. After drying the applied frit glass, the supporting frame 104 constituting the outer circumference is inserted between the face plate 102 and rear plate 103 with a given space apart between them. The rear plate and face plate is fixed by applying a load from upward and downward, and the assembly is heated at a softening temperature of the

frit glass 101 followed by cooling. The imaging device is hermetically sealed as shown in Fig. 7.

[0012]

[Problems to be Solved by the Invention] Since the electron emission element of the imaging device as described above is operated in a vacuum of about 10^{-6} Torr, the device should be a vacuum vessel durable to the atmospheric pressure.

[0013] The thickness of each structural member such as the rear plate and face plate should be large, and the supporting frame should be wide in order to form an imaging device having a structure safe and resistant to the atmospheric pressure.

[0014] However, the imaging device becomes so heavy by increasing all the thickness of the structural members when a large screen size (for example 60 inch) imaging device is produced. Increasing the weight is disadvantageous for transfer and installation of the imaging device, and application field thereof is narrowed.

[0015] Accordingly, the vacuum vessel of the imaging device should be efficiently made lightweight by changing the shape of the constituting members without impairing the strength of the atmospheric pressure resistance.

[0016] The object of the invention considering the situations of the usual art is to provide an imaging device efficiently made to be lightweight without reducing the

strength as an atmospheric pressure resistant structure.

[0017]

[Means for Solving the Problems] The invention for attaining the object above provides an imaging device formed as a hermetic structure with a rear plate mounting elements and electrodes, a face plate disposed facing the rear plate and mounting an imaging member, and a supporting frame disposed between the rear plate and face plate, wherein the width of the supporting frame is not uniform with a minimum with at the corners of the supporting frame, and side faces of the outer circumference of the supporting frame is outwardly swelled.

[0018] The imaging device may have an outer circumference of the supporting frame having a shape comprising a plurality of curved surfaces, or the side faces of the outer circumference of the supporting frame may have a shape comprising a plurality of curved surfaces and a plurality of planes.

[0019] The curved surface may be a part of the side face of a circular column or ellipsoidal column, the supporting frame may comprise a plurality of side walls, or the supporting frame may comprise a plurality of side walls and a plurality of reinforcing walls.

[0020] Preferably, at least one of the face plate and rear plate has the same shape as the shape of the side faces of

the outer circumference of the supporting frame.

[0021] The imaging device may utilize a surface conduction electron emission element as the element, or the imaging device may be a gas discharge imaging device or a thermoelectron imaging device.

[0022]

[Operation] Each member constituting the imaging device as a vacuum vessel suffers an atmospheric pressure in the invention so constituted as described above. Since the rear plate and face plate are bent by the atmospheric pressure, a compression stress acts on the inner circumference side faces in a direction perpendicular to the plate surfaces of the rear plate and face plate (named as "z-direction" hereinafter), and an extension stress for pulling in the z-direction acts on the outer side faces in the supporting frame for resisting deformation.

[0023] When a supporting frame having an approximately uniform width is used in the imaging device having an approximately rectangular shape, the maximum extension stress acting on the outer circumference faces of the supporting frame is generated at the center of the side faces in the major axis direction of the circumference of the supporting frame. A maximum stress is also applied at the center in the minor axis direction of the outer circumference of the supporting frame. On the other hand,

the extension stress generated at the peripheral portion of the four corners of the side faces of the outer circumference of the supporting frame is small.

[0024] Accordingly, the width of the supporting frame is defined at the portions suffering a small extension stress, while a larger width of the frame is defined at the portions suffering a larger extension stress. In other words, the width of the supporting frame is not uniform. The corners of the supporting frame have a minimum with, while the side faces of the circumference of the supporting frame is swelled toward the outside to permit the distribution of the extension stress to be approximately uniform over the entire circumference of the supporting frame.

[0025] Consequently, the volume of the supporting frame may be reduced without causing a decrease of the design strength, and the imaging device may be efficiently lightweight.

[0026]

[Examples] Examples of the invention will be described below with reference to the drawings.

[0027] (First embodiment) Fig. 1 shows the construction of the first embodiment of the imaging device of the invention. Fig. 1 is a partially cut perspective view, and Fig. 2 shows a plane view of the supporting frame shown in Fig. 1.

[0028] The imaging device shown in Fig. 1 comprises a rear plate 1 mounting a group of electron emitting elements (not

shown) and electrodes (not shown), a face plate 2 disposed facing the rear plate 1 and mounting an imaging member for forming an image by irradiating an electron beam from the group of the electron emitting elements, and a supporting frame 3 disposed between the face plate 2 and rear plate 1 and supporting the peripheral circumference of the face plate 2 and rear plate 1 so as to surround the group of the electron emission elements. The joints between the face plate 2 and supporting frame 3, and between the rear plate 1 and supporting frame 3 are bonded with a frit glass. The imaging device is formed as a hermetic vessel having the structure described above.

[0029] The thickness of the supporting frame 3 in the direction perpendicular to the panel surface of the rear plate 1 or face plate 2 (z-direction in the drawing) is uniform.

[0030] The shape of the supporting frame will be described below with reference to Fig. 2.

[0031] The width of the frame was determined so that the maximum extension stress at the center of each edge of the supporting frame 3, when the face plate 2 (see Fig. 1) and rear plate 1 (see Fig. 1) are bent to the inside of the vacuum vessel, is an allowable limiting value (an allowable value against the maximum extension stress for satisfying a design strength considering safety) of the supporting frame.

The shape of the supporting frame 3 was determined thereafter using a part of a curve (approximately an arc in the invention) so that the maximum extension stress generated at four corners of the circumference comes approximately close to the allowable limiting value. Consequently, the maximum extension stress generated at the supporting frame 3 could be adjusted to near the allowable limiting value or below the allowable limiting value.

[0032] Actually, a blue sheet glass having a screen size of 60 inches with a thickness of the rear plate 1 (see Fig. 1) and a thickness of the face plate 2 (see Fig. 1) of 60 mm was used, and the blue sheet glass was processed as a supporting frame 3 having a height of 5 mm.

[0033] The inner circumference of the supporting frame 3 was a rectangle with a major edge length of 1.4 mm and minor edge length of 0.8 mm. A part of a circle with a radius of about 12.9 mm was used so that the maximum width at the major edge side is 50 mm, and a part of a circle with a radius of about 9.3 mm was used so that the maximum width at the minor edge side is 40 mm for the outer circumference. Actually, a part of a round column having the radius as described above was used. About 3% of reduction of the weight was possible by using the rear plate 1 (see Fig. 1) and face plate 2 (see Fig. 2) having the same shape as the shape of the outer circumference.

[0034] While the supporting frame shown in Fig. 1 is a monolithic frame, it is effective to manufacture the frame by assembling a plurality of side walls.

[0035] Fig. 3 shows an example of another construction of the supporting frame.

[0036] In Fig. 3, the supporting frame 3 comprises two side walls 4 constituting the major edge of the frame, and two side walls 5 constituting the minor edge of the frame bonded with each other.

[0037] While constituting the frame with four side walls is described herein, the number of the side walls and the assembling method thereof are not restricted at all.

[0038] While the face plate 2 and rear plate 1 having the shapes along the outer circumference of the supporting frame 3 were used in this example, any shapes may be available so long as the bonding area between the rear plate 1 or face plate 2 and supporting frame 3 is not reduced, or the size of the rear plate 1 or face plate 2 is the same as or larger than the size of the outer circumference of the supporting frame 3. However, it is desirable for the purpose of lightweight that the shape of the outer circumference of the supporting frame 3 is the same as the shapes of the rear plate 1 and face plate 2. This is the same in all the examples describing the invention.

[0039] (Second Embodiment) Fig. 4 is a plane view showing

the supporting frame in the second embodiment of the imaging device of the invention.

[0040] The imaging device of the invention has a supporting frame 7 as shown in Fig. 4. Actually, this supporting frame 7 comprises two rectangular side walls 8 constituting the major edges of the frame and two rectangular side walls 9 constituting the minor edges of the frame bonded with each other with a frit glass 10. The two side walls 8 are reinforced with reinforcing walls 12, respectively, and two side walls 9 are reinforced with reinforcing walls 11, respectively, by bonding with the frit glass 10.

[0041] Each side walls 8 and each side walls 9 were determined to have uniform widths, respectively, in this example so that the maximum extension stress generated at four corners of the circumference fall within an allowable maximum limit value at the side faces of the circumference of the supporting wall. Since the maximum extension stress is generated at the central portion of the side faces of the outer circumference of each side wall, the reinforcing wall 11 and reinforcing wall 12 were added at the outside of the side walls 8 and side walls 9. Consequently, the extension stress at each part of the supporting wall could be controlled to be approximately the same as or lower than the allowable limiting value.

[0042] A part of an ellipsoid was used as the shape of the

reinforcing wall of the invention.

[0043] The frame width was determined so that the extension stress at the part suffering the smallest extension stress at the outer circumference side faces of the frame falls within the allowable limiting value in this example, and the frame width was increased at the portion suffering a large extension stress to efficiently make the frame lightweight.

[0044] The cold cathode electron source described in the related art may be used as the plural elements mounted on the rear plate in the first and second embodiments. The construction of the surface conduction electron emission element will be briefly described as an example of the cold cathode electron sources. Fig. 5 illustrates an example of the basic construction of the surface conduction electron emission element, wherein Fig. 5(a) is a plane view and Fig. 5(b) is a vertical cross section thereof.

[0045] The surface conduction electron emission element shown in Fig. 5 comprises an insulating substrate 21, and element electrodes 25 and 26 are disposed on the insulating substrate 21 with a given distance apart L1. A thin film conductor 24 is formed between the element electrodes 25 and 26 on the insulating substrate 21. An electron emission part 23 for emitting electrons is formed on the thin film conductor 24 by heating the thin film conductor 24 by flowing an electric current (Japanese Patent Application

Laid-Open Nos. 2-56822 and 4-28139).

[0046] The electron emission part 23 comprises conductive fine particles with a particle diameter of several tens angstrom, and the thin film conductor 24 except the electron emission part 23 comprises the fine particle film.

[0047] The fine particle film as described herein is a film comprising a plurality of aggregated fine particles. The fine structure thereof comprises not only respective dispersed particles, but also adjoining fine particles or overlapped fine particles (including islets of the particles).

[0048] Apart from the example above, the thin film conductor 24 includes a carbon fine film the conductive thin particles in which conductive fine particles are dispersed.

[0049] Examples of the thin conductor 24 include metals such as Pb, Ru, Ag, Ti, In, Cu, Cr, Fe, Zn, Sn, Ta, W and Pb; oxides such as PbO, SnO_2, In_2O_3 and Sb_2O_3; borides such as HfB_2, ZrB_2, LaB_6 CeB_6, YB_4 and GdB_4; carbides such as TiC, ZrC, HfC, TaC, SiC and WC; nitrides such as TiN, ZrN and HfN; semiconductors such as Si and Ge; and carbon, AgMg and NiCu.

[0050] The thin film conductor 24 is formed by a vacuum vapor deposition method, sputtering method, chemical vapor deposition method, dispersion coating method, dipping method and spinner method.

[0051] An example of the method for manufacturing the

surface conduction electron emission element will be described hereinafter. In Fig. 5, a blue sheet glass was used as an insulating substrate 21, and element electrodes 25 and 26 were formed on the insulating substrate 21 using Ni. The distance L1 between the element electrodes was 3 µm, the width W1 of the element electrode was 500 µm, and the thickness d of the element electrode was 1000Å.

[0052] After coating organic palladium (ccp-4230 produced by Okuno Seiyaku Co.) at a desired site including the element electrode, the thin film conductor 24 comprising palladium oxide (PdO) fine particles (average diameter: 70Å) was formed by heat treating at 300 degree for 10 minutes. The width W2 of the thin film conductor 24 was 300 µm.

[0053] The FE and MIM electron emission elements described in the related art may be used in the innovation in place of the surface conduction electron emission element.

[0054] (Third embodiment) The frame shown in the first and second embodiments was applied for a gas discharge imaging device (not shown). The manufacturing method thereof will be briefly described below.

[0055] A discharge electrode generating a discharge plasma is placed on a rear plate made of a glass. Then, an electron induction electrode was disposed for inducing electrons from the discharge plasma. The electron induction electrode comprises a metal plate having regularly arranged

many through-holes. A control electrode comprising a group of belt electrodes were disposed on a sheet of the insulating substrate. The control electrode has through holes being coaxial with the through holes on the electron inducing electrode so that linear passageway of electrons is not blocked.

[0056] A glass face plate having an adhere fluorescent film is disposed thereafter so that it is faced in parallel to the induction electrode formed on the rear plate. The glass supporting frame having the shape shown in the first and second embodiments were inserted between the face plate and rear plate, and the panels were hermetically sealed with the frit glass.

[0057] After sealing, the inside of the imaging device was evacuated, and the gas discharge imaging device was manufactured by sealing a low pressure rare gas.

[0058] The imaging device was made to be more lightweight by providing a frame width corresponding to the extension stress at the side faces of the outer circumference of the supporting frame.

[0059] (Fourth embodiment) The frame shown in the first embodiment was applied to a fluorescent imaging tube in this embodiment. The method for manufacturing the imaging tube will be briefly described below.

[0060] A conductive film constituting inner wiring

connections and connection terminals thereof are printed on the glass rear plate, and an insulating film having through-holes was further formed on the surface of the wiring connections on the rear plate. Anode segments having a fluorescent material on the surface were deposited as a laminated on the surface of the insulating film. The plural anode segments are disposed so that a pair of the segment groups is able to display desired letters, numerals and signs by selected combinations thereof, and these juxtaposed plural unit segment groups are able to display desired fluorescence images. A grid electrode is placed above the anode segment with interposition of a grid holder, and a cathode filament was extended between the two filament holders above the grid electrode. The grid electrode is fixed with a conductive adhesive with interposition of the grid holder, and the grid electrode is electrically connected to the wiring connection through the electrical connection holes formed on the insulating film.

[0061] The glass face plate is disposed so as to face in parallel to the rear plate thereafter, and the glass supporting frame having the shape shown in the first and second embodiment was inserted between the face plate and rear plate followed by hermetically sealing with the frit glass.

[0062] after sealing, the inside of the imaging device was

evacuated to vacuum to produce the fluorescent display tube.

[0063] The display tube as efficiently made to be lightweight by setting a frame width corresponding to the extension stress at the side faces of the outer circumference of the supporting frame.

[0064]

[Advantages] As described above, the rear plate and face plate is bent into the inside of the vacuum vessel in the invention, and an extension stress is applied to the side faces of the outer circumference of the supporting frame that prevents the vessel from being deformed. However, the width of the supporting frame is determined corresponding to the stress distribution on the side faces of the outer circumference of the frame so that the width is fixed at the portion suffering a small extension stress, while a wide frame width is selected at the portion suffering a large extension stress corresponding to the extension stress. Consequently, the extension stress distribution is maintained to be approximately uniform over the entire circumference of the supporting frame.

[0065] Accordingly, the volume of the supporting frame may be reduced without impairing the strength of the atmospheric pressure resistant structure as a vacuum vessel, when the imaging device such as the imaging device using the surface conduction electron emission element, or gas discharge

imaging device and fluorescent display tube is made to be large size. Consequently, the imaging device may be efficiently made to be lightweight. The invention enables an imaging device that is light and convenient for transfer and installation to be manufactured.

[Brief Description of the Drawings]

[Fig. 1] Fig. 1 is a partially cut off perspective view showing the first embodiment of the imaging device of the invention.

[Fig. 2] Fig. 2 is a plane view of the supporting frame shown in Fig. 1.

[Fig. 3] Fig. 3 shows another construction of the supporting frame.

[Fig. 4] Fig. 4 is a plane view showing the supporting frame in the second embodiment of the imaging device of the invention.

[Fig. 5] Fig. 5 shows a basic constitution of the surface conduction electron emission element, wherein Fig. 5(a) shows a plane view while Fig. 5(b) a vertical cross section thereof.

[Fig. 6] Fig. 6 is a disassembled perspective view for illustrating the construction of the usual imaging device.

[Fig. 7] Fig. 7 is a vertical cross section of the imaging device shown in Fig. 6.

[Reference numerals]

1	rear plate
2	face plate
3, 7	supporting frame
4, 5, 8, 9	side wall
6, 10	frit glass
11,12	reinforcing wall
21	insulating substrate
23	electron emission part
24	thin film conductor
25, 26	element electrode

Fig. 1

1 rear plate

2 face plate

3 supporting frame

Fig. 2

3 supporting frame

frame width

Fig. 3

3 supporting frame

4 side wall

5 side wall

6 frit glass

Fig. 4

7 supporting frame

8 side wall

9 side wall

10 frit glass

11 reinforcing wall

12 reinforcing wall

Fig. 5

21 insulating substrate

23 electron emission part

24 thin film conductor

25 element electrode

26 element electrode

Fig. 6

101 frit glass

102 face plate

103 rear plate

104 supporting plate

Fig. 7

101 frit glass

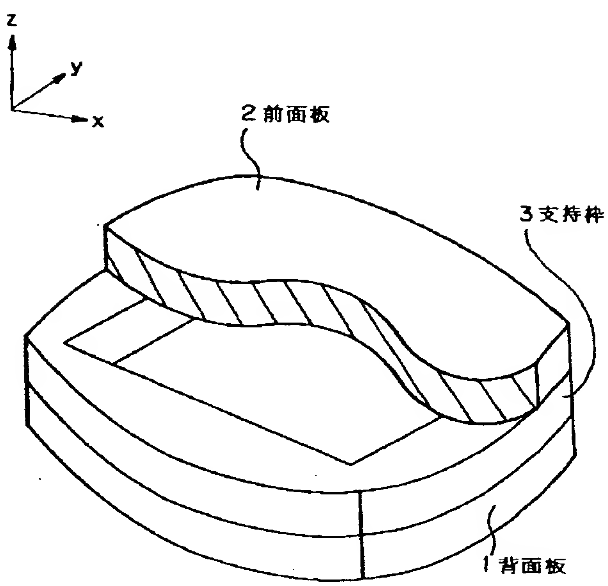
102 face plate

103 rear plate

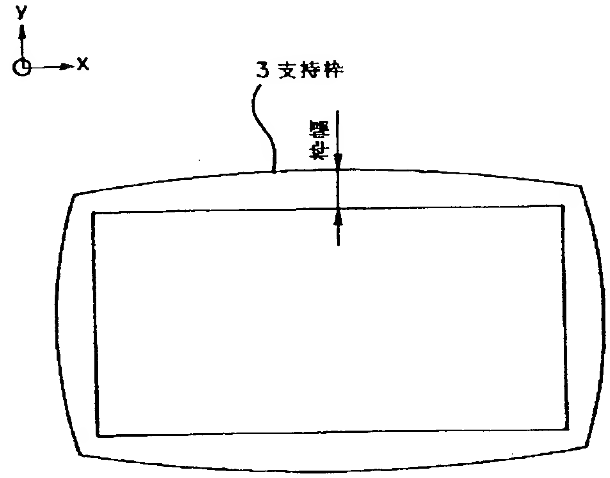
104 supporting plate

6，１０　　フリットガラス
１１，１２　　補強壁
２１　　絶縁性基板
２３　　電子放出部
２４　　薄膜導電体
２５，２６　　素子電極

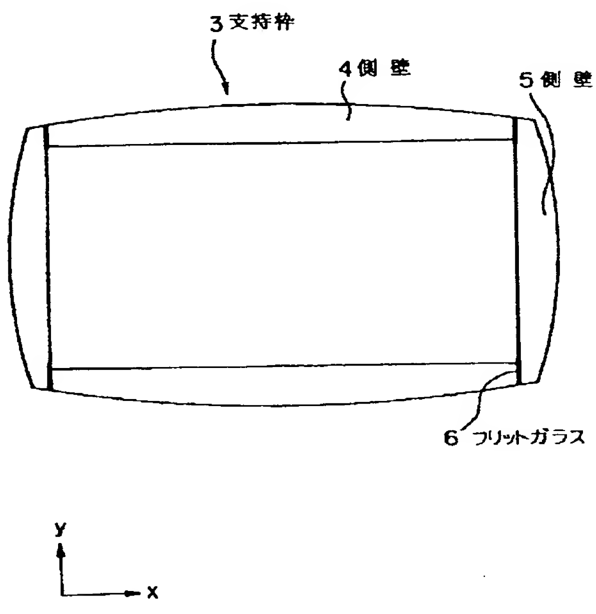
【図1】 FIG.1



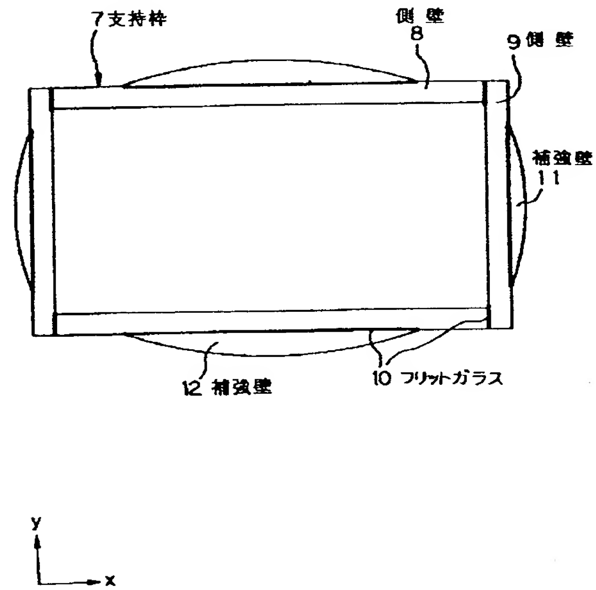
【図2】 FIG.2



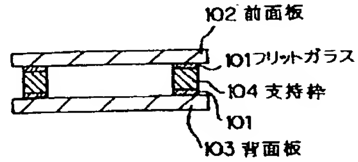
【図3】 FIG.3



【図4】 FIG.4

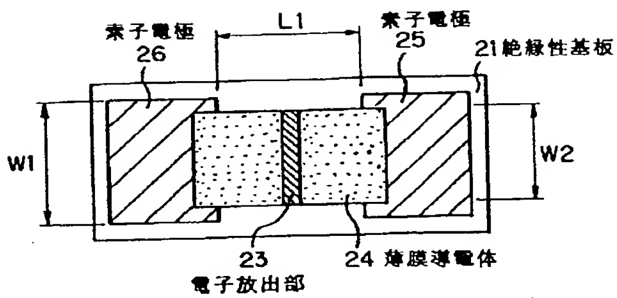


【図7】 FIG.7

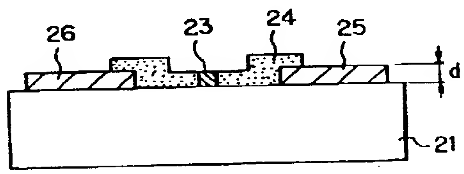


【図5】 FIG.5

(a)



(b)



【図6】 FIG.6